# Chapter 5
# Traditional Agroforestry Systems and Their Evolution in Greece

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**Abstract** Agroforestry systems are a traditional land use practice in Greece. They are widely distributed all over the country and constitute important elements of the rural landscape. They include all three types of systems: silvoarable involving trees and crops grown on arable land, silvopastoral involving trees and pasture/animals grown on forest and arable land and agrosilvopastoral involving trees, crops and grazing animals grown on arable land. Trees may be forest species or cultivated trees grown for fruits, naturally regenerating or planted, evergreen or deciduous; crops may be annual or perennial species; and animals may be sheep, goats, cattle, pigs or chicken. The area covered by these systems is estimated to be more than 3 million hectares or 23% of the whole country. All types of systems deliver a great variety of goods and services and constitute a cultural heritage while the role of trees is crucial in sustaining production and improving the environment in rural areas. Despite their great economic, ecological and cultural importance however traditional agroforestry systems have been degraded over the last few decades due to extensification/intensification processes imposed by socio-economic changes. In this paper, after describing the most prominent traditional agroforestry systems and analysing their economic, ecological and cultural roles, their recent evolution is discussed and recommendations are made for their inventory, conservation and sustainable management.

**Keywords** Classification, cultural aspects, kermes oak, olive tree, valonia oak, walnut systems

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## Agroforestry Systems in Greece: Historic Perspective

In Greece, agroforestry dates back to the Neolithic period when forests were opened up by cutting or burning by man in order to accommodate grazing for domesticated livestock resulting in the creation of silvopastoral systems. Grove and Rackham (2001) however claim that open forests of savannah-type were already present naturally in the Mediterranean region during that early period where wild or domesticated animals were grazing. On the other hand, when agriculture was developed and several forests were cleared to be converted into arable land, trees of the original forest were left inside or in the borders of the farm in order to accommodate additional needs of the people for firewood, fruits or foliage for their animals. Those relict trees in farms created the first silvoarable systems.

The deliberate incorporation of trees into farming systems, which constitutes the essence of modern agroforestry science (Nair 1993), started much later when olive and other fruit trees such as sweet chestnut (*Castanea sativa* Mill.) and walnut (*Juglans regia* L.) were introduced into the Greek farming systems (Schultz et al. 1987). According to Sallares (1991), the intercropping of olive trees (*Olea europaea* L.) and cereals or legumes was widespread in Greece during the first millennium BC because it was more productive than monocultures of any of these plants. This practice has been continued ever since with other forest species resulting in the development of a large variety of silvoarable systems. Over the centuries, both silvopastoral and silvoarable systems survived due to their ability to meet the multiple needs of the people thus becoming part or even the dominant feature of the landscape (Ispikoudis et al. 1996).

In the last few decades however most of the traditional agroforestry systems are threatened by degradation either through abandonment or intensification, which leads to their conversion to woodlands and crop monocultures, respectively. This paper presents an analysis and evaluation of agroforestry systems in Greece exploring and discussing at the same time their future evolution.

## Structure, Extent and Uses of Agroforestry Systems

### *Agroforestry Systems Defined*

In their attempt to document agroforestry systems of Greece for the first time, Schultz et al. (1987) defined agroforestry as “a general name for land management practices in which trees are grown together with agricultural crops and/or animals”.

In the present work, we have adopted the same definition. A tree is considered as any single-stemmed woody species more than 5 m high. This means that we do not include under agroforestry systems the shrublands where the woody species

are multi-stemmed (shrubs or shrubby trees) and usually less than 5 m high. As crops we consider any herbaceous species as well as vines, which are cultivated in the understory or between trees (intercropping). As animals we mainly consider ruminants such as sheep, goats and cattle, but we do not exclude other domestic animals as well (pigs, horses, chickens, etc). All these animal species may be fed or directly graze in the understory on artificially established forage crops or, most commonly, on natural vegetation (pasture), herbaceous or woody (shrubby) species.

## *Classification of Agroforestry Systems*

Schultz et al. (1987) separated agroforestry systems of Greece into two groups, those found on agricultural land, which is normally privately owned, and those found on forest land, which belongs to the Government or to other non-public organizations. In the first group, agroforestry systems usually consist of two components, trees and crops. Trees may be found or planted isolated, in groups or in lines (e.g. windbreaks) within the arable fields or in their borders, while crops are usually cereals thus resulting in silvoarable systems. Rarely crops are forage species directly grazed by livestock suggesting that very few of these systems may function as silvopastoral. On the contrary, quite a few of them may be grazed after the harvest of the cereal crop thus becoming agrosilvopastoral involving three components, namely trees, crops and animals. The second group on forest land can be classified as silvopastoral systems because they involve trees and animals grazing on the understory which is a natural pasture with herbaceous or woody (shrubby) species. These systems include open forests as well as denser ones that support herbaceous or shrubby vegetation and can be grazed without significantly impairing wood production and other forest values (Papanastasis 1996). Consequently, these grazable forests (or forest grazing) are also considered as silvopastoral systems.

It should be noted that silvopastoral systems are important grazing lands for livestock. Greece has 5.4 million goats, which correspond to more than 43% of the goat population of the 25 member countries of the European Union (Eurostat 2002). Most of these goats graze on silvopastoral systems. In addition, sheep amounting to 8.8 million heads and to a lesser extent cattle amounting to 600 hundred thousand heads depend on these systems, too.

Table 5.1 shows the prominent agroforestry systems based on the dominant tree of the overstory. It must be noted that although all these systems form pure stands, in several of them the dominant tree species is grown together with other tree species as well resulting in mixed agroforestry systems. Table 5.1 also shows that the structure of the understory is quite variable, depending on the particular ecological zone and the geographical area where the system is distributed; the mentioned products/uses refer to both the overstory and the understory or to the system as a whole.

**Table 5.1** Prominent agroforestry systems of Greece classified according to the dominant tree species (systems with bold numbers are described in detail in the text)

| Dominant tree species | Main understory species | Region | Main products/uses |
|---|---|---|---|
| **1 Natural coniferous** | | | |
| 1.1. *Abies cephalonica* | Herbaceous | Central Greece, Peloponnesus | Timber, forage |
| 1.2. *Abies borisii-regis* | Herbaceous | Pindus mountain range | Timber, forage |
| **1.3.** *Pinus halepensis* | Evergreen shrubs | Attica, Euboea, Kassandra | Resin, fuelwood, timber, forage, honey, |
| **1.4.** *Pinus brutia* | Evergreen shrubs | Crete, Thassos, Dadia, Aegean islands | Timber, fuelwood, honey, forage, resin, |
| 1.5. *Pinus nigra* | Herbaceous | Pindus mountain range | Timber, electricity poles, forage |
| 1.6. *Pinus leucodermis* | Herbaceous | Pindus mountain range | Timber, barrel wood, forage |
| 1.7. *Pinus pinea* | Herbaceous, evergreen shrubs | Peloponnesus | Forage, timber, pine nuts |
| 1.8. *Pinus silvestris* | Herbaceous | Macedonia, Thrace | Timber, electricity poles, forage |
| **1.9.** *Cupressus sempervirens* | Evergreen shrubs | Crete, Aegean islands | Forage, timber |
| **2. Natural broadleaved evergreen** | | | |
| **2.1.** *Quercus coccifera* | Evergreen shrubs, phrygana | Crete | Forage, acorns, fuelwood |
| 2.2. *Quercus ilex* | Evergreen shrubs | Western Greece | Charcoal, fuelwood, forage |
| **3. Natural broadleaved deciduous** | | | |
| **3.1.** *Quercus ithaburensis ssp. macrolepis* | Phrygana, herbaceous, arable crops | Western Greece, mainland, Aegean islands | Forage, fuelwood, acorns, cereals |
| **3.2.** *Quercus trojana* | Herbaceous, deciduous shrubs, arable crops | Western Macedonia, Thrace, Thessaly | Fuelwood, cereals, forage, timber, fodder, acorns |
| **3.3.** *Quercus pubescens* | Herbaceous, deciduous shrubs, arable crops | Various places in mainland | Timber, fuelwood, fodder, cereals, forage, acorns |
| **3.4.** *Quercus frainetto* | Herbaceous, deciduous shrubs, arable crops | Various places in mainland | Timber, fuelwood, fodder, cereals, forage, acorns |
| **3.5.** *Quercus petraea* | Herbaceous, deciduous shrubs, arable crops | Thessaly, Macedonia | Timber, fuelwood, fodder, cereals, forage, acorns |
| **3.6.** *Quercus cerris* | Herbaceous, deciduous shrubs, arable crops | Thessaly, Western Macedonia, Thrace | Fuelwood, forage, cereals, fodder, acorns |
| 3.7. *Castanea sativa* | Herbaceous, arable crops | Various places in mainland | Poles, fuelwood, fruits, fodder, honey, mold |

(continued)

**Table 5.1** (continued)

| Dominant tree species | Main understory species | Region | Main products/uses |
|---|---|---|---|
| 3.8. *Fagus silvatica* | Herbaceous, potato crops | Northern Greece | Timber, forage, potatoes |
| 3.9. *Pyrus amygdaliformis* | Herbaceous, deciduous shrubs, arable crops | Various places in mainland | Forage, fuelwood, cereals, fruits |
| 3.10. *Acer campestre* | Herbaceous, deciduous shrubs | Epirus, Central and Northern Greece | Fuelwood, forage |
| 3.11. *Celtis australis* | Herbaceous, arable crops | Northern Greece | Fuelwood, forage, timber, fruits |
| **4. Cultivated conifers** | | | |
| **4.1.** *Cupressus sempervirens* | Arable crops, herbaceous | In various plains | Windbreaks, agricultural products, timber |
| **5. Cultivated broadleaved evergreen** | | | |
| **5.1.** *Olea europea* | Arable crops, herbaceous | Mainland and islands | Olives, forage, fodder, cereals, grapes, fuelwood, wood |
| 5.2. *Ceratonia siliqua* | Herbaceous, arable crops | Crete, Peloponnesus, Aegean islands | Fruits, forage, cereals, grapes, fuelwood |
| **6. Cultivated broadleaved deciduous** | | | |
| **6.1.** *Populus thevestina* | Arable crops | Macedonia, Thrace | Timber, vegetables |
| **6.2.** *Populus* (clones) | Herbaceous, arable crops | Macedonia, Thrace, Thessaly | Timber, vegetables, forage |
| **6.3.** *Juglans regia* | Arable crops, herbaceous | Various places | Timber, nuts, cereals, grapes, forage |
| **6.4.** *Prunus amygdalus* | Arable crops, herbaceous | Mainland and islands | Almonds, grapes, cereals, fuelwood, forage |
| 6.5. *Ficus carica* | Arable crops, phrygana | Mainland and islands | Fruits, grapes, cereals, forage |
| 6.6. *Robinia pseudoacacia* | Arable crops, herbaceous | Various places in mainland | Timber, honey, fodder, forage |
| 6.7. *Morus alba* | Arable crops, herbaceous | Evros, Chalkidiki, Thessaloniki, Crete | Foliage (for silkworms), fodder, fuelwood, cereals, forage, fruits |
| 6.8. *Castanea sativa* | Herbaceous | Various places in mainland | Timber, fruits, forage |
| 6.9. *Prunus avium* | Arable crops | Various places in mainland | Fruits, cereals, vegetables, grapes, forages, fuelwood |
| 6.10. *Malus communis* | Arable crops | Various places in mainland | Fruits, cereals, vegetables, grapes, forages, fuelwood |
| 6.11. *Pyrus communis* | Arable crops | Various places in mainland | Fruits, cereals, vegetables, grapes, forages, fuelwood |

(continued)

**Table 5.1** (continued)

| Dominant tree species | Main understory species | Region | Main products/uses |
|---|---|---|---|
| 6.12. *Prunus persica* | Arable crops | Central and Northern Greece | Fruits, cereals, vegetables, grapes, forages, fuelwood |
| 6.13. *Prunus armeniaca* | Arable crops | Various places in mainland | Fruits, cereals, vegetables, grapes, forages, fuelwood |
| 6.14. *Prunus domestica* | Arable crops | Various places in mainland | Fruits, cereals, vegetables, grapes, forages, fuelwood |
| 6.15. *Cydonia oblonga* | Arable crops | Various places in mainland | Fruits, cereals, vegetables, grapes, forages, fuelwood |

## *Area Covered*

There is no information on the exact area covered by agroforestry systems in Greece. As a matter of fact, no such land use is designated anywhere in the official national statistics. In order to arrive at some estimates, we used indirect statistical data and educated guesses.

For the agroforestry systems on forest land we used the latest official inventory of the Forest Service for the various types of forests (Ministry of Agriculture 1992). More specifically, we considered as agroforestry systems all forests which are open (less than 100 $m^3$ $ha^{-1}$ of timber stock) and have trees with measurable DBH, i.e. >5 cm. We assumed that such forests have a crown canopy cover less than 40% and support an understory with herbaceous or woody vegetation that provides forage to livestock thus making grazing management their primary objective (Papanastasis 1996). Such systems amount to 1,079,611 ha or 32% of the total area of the industrial (high) forests (Table 5.2). This figure is a conservative estimation because it does not include the grazable forests, namely the forests that have a crown canopy of about 40–60% and support some understory vegetation that can be grazed by livestock but grazing management is a secondary objective to timber management. The exact area of grazable forests is not known, but if we take into account that most forests are grazed by livestock, we can claim that the agroforestry systems on forest land amount to more than 2 million hectares. The kind of forests subjected to livestock grazing include the so called Mediterranean forests, i.e. Aleppo pine (*Pinus halepensis* Mill.)and brutia pine (*Pinus brutia* Ten.) forests, most of the mountainous pine forests [e.g. Austrian pine (*P. nigra* Arn.),Scots pine (*P. sylvestris* L.) and Heildrich pine (*P. leucodermis* Ant.)] and the deciduous oak forests, especially the ones with a coppice form (Liacos 1980; Papanastasis 1986).

For the agroforestry systems on agricultural land we used the data of the National Statistical Service of Greece (2005). We assumed that agroforestry systems exist in the whole agricultural area of Greece amounting to 3,483,200 ha except in areas

**Table 5.2** Area (in ha) covered by agroforestry systems on forest land[a]

| Forest type | Timber stock ($m^3$ $ha^{-1}$) | Area with measurable trees (DBH ≥ 5 cm) | Area without measurable trees (DBH < 5 cm) | Estimated area of agroforestry systems[b] |
|---|---|---|---|---|
| Industrial | 0[c] | 57,359 | 505,988 | 57,359 |
| | 1–100 | 1,022,252 | 1,283,358 | 1,022,252 |
| | >100 | 404,876 | 85,353 | – |
| Non-industrial[d] | 0 | – | 3,153,882 | – |
| Total | | 1,484,487 | 5,028,582 | 1,079,611 |

[a] Data from Ministry of Agriculture (1992)
[b] Grazable forests (forest grazing) are not included in this area (see text for explanations)
[c] About 10% of the area of this class was found to have trees with measurable DBH
[d] This category represents shrublands with no measurable trees and timber stock

**Table 5.3** Area (in ha) covered by agroforestry systems on agricultural land[a]

| Group of tree species | Individual species | Estimated area[b] |
|---|---|---|
| Natural | Oaks, wild pears and other forest trees | 843,700 |
| Cultivated | | |
| Citrus trees | Orange, lemon, mandarin, etc. | 6,498 |
| Fruit trees | Apple, pear, peach, apricot, cherry, etc. | 17,770 |
| Nut and dried fruit trees | Almond, walnut, chestnut, carob, fig, etc. | 41,352 |
| Olive trees | Both for edible olives and olive oil | 124,311 |
| Other trees | Plum, mastic, poplars, cypress, etc. | 11,244 |
| Total | | 1,044,875 |

[a] Data from National Statistical Service of Greece (2003)
[b] See text for explanation

where land consolidation or reclamation was carried out followed by irrigation, which resulted in the removal of almost all the naturally grown trees. Consequently, we subtracted the irrigated area from the total agricultural area as well as the area under pure tree plantations (monocultures) and arrived to a figure of 1,044,875 ha, which represents 30% of the whole agricultural area (Table 5.3). This area includes agroforestry systems with both naturally occurring and cultivated trees. For the latter, we estimated their area using the data of the National Statistical Service of Greece (2005) for the cultivated trees planted out of pure plantations (monocultures). The results are shown in (Table 5.3) and indicate that such systems represent 19% of the whole area of agroforestry systems on agricultural land. This figure however is a conservative estimate because we assumed that these trees are planted in the same densities as the ones in pure plantations, which is not true. Nevertheless, it represents the closest estimation we can get with the available data.

## *Cultural Aspects*

Agroforestry systems have a rich cultural history and constitute examples of traditional lifestyles and techniques. They represent management practices that are based

on a body of local or indigenous technical knowledge, which has evolved over time in response to the vagaries of ecological, economical and political circumstances. They are a cultural, social, economic and ecological heritage of the people.

An important element of the traditional agroforestry systems is tree management (Fig. 5.1). Two techniques have been used, shredding and pollarding. Shredding

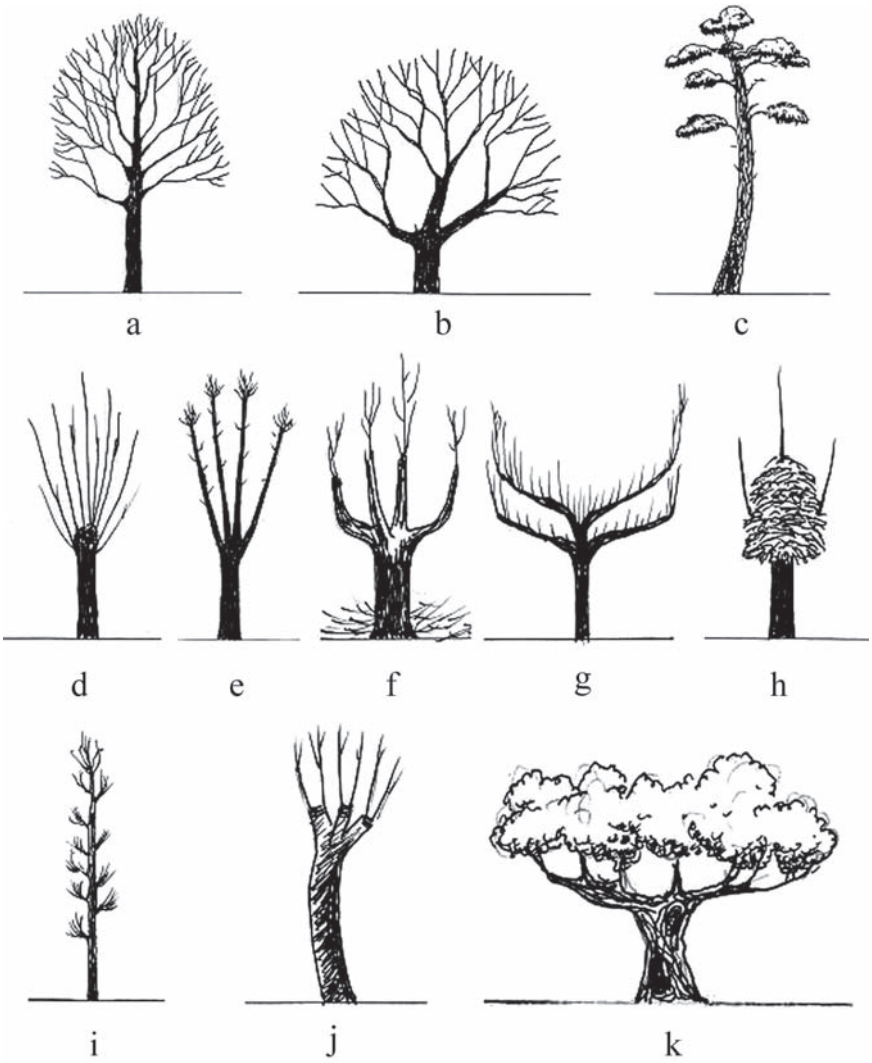


**Fig. 5.1** Traditional tree management schemes: (a) non-managed tree, (b) managed walnut tree for a trunk of high timber quality, (c) pruned Aleppo pine tree for ship building timber, (d) pollarded tree of any species for fodder, (e, f) pollarded oak trees for fodder (g) pollarded mulberry tree for fodder, (h) pollarded tree for storage of fodder, (i) shredded oak tree for fodder (j) grafted tree for fruit production and (k) lopped olive tree for olives and fodder production (Drawings by I. Ispikoudis)

consists of cutting the lower branches of the tree for fodder, while pollarding involves cutting off the branches of a tree at a height at least 1.5–2 or 3 m of the trunk so that the new sprouts are out of the reach of the animals. The trees are first cut when they are 10–15 years old or when the stem diameter exceeds 15 cm. The technique of pollarding was a way of protecting the trees from browsing and/or cultivation practices. It seems that these techniques extend the life of a tree. The etymology of the Greek word 'koura' implies exactly this thing, since it derives from the words 'kouros' (young) and 'kourizo' (make young). 'Kouri' is also a place name, found all over Greece. All the places named 'kouri' are situated in areas where there was a high grazing pressure. The majority of the places named 'kouri' coincide either with areas or with the paths of transhumance (Ispikoudis et al. 2004).

Leaf and twig fodder cut from trees played a major role in animal husbandry and in many areas; stored hay was of critical importance to the survival of livestock during the winter period. This is because in many areas, mainly in uplands, winters are too cold and long for livestock to graze outdoors and they have to be penned in barns for three to six months (Halstead 1998). In addition, leaf and twig fodder harvesting also played a major role in shaping the cultural landscapes in Greece and in particular the structure and composition of vegetation. A whole cultural landscape with various forms of at least seven species of deciduous oaks has been created by the people called 'koupatsari', the oak people (Grove and Rackham 2001).

Tree fodder harvesting must have greatly influenced the Greek landscape. According to Halstead (1998), arboreal fodder has played a critical role in maintaining and shaping farming in agriculturally marginal environments. Also, shredding and pollarding of beech (*Fagus* spp.) and oak (*Quercus* spp.) trees had a widespread and drastic impact on the landscape of the mountains of Greece. Halstead (1998) has estimated that when a Greek village collectively owned around 2,000 sheep and goats the villagers would have to shred between 3,000 and 10,000 mature oaks.

## Description of the Most Important Agroforestry Systems

Although Greece has still a great variety of traditional agroforestry systems, not all of them are equally important in terms of area covered. In this section, the most common and widespread systems are described following the classification proposed in the previous section and presented in Table 5.1. No distribution maps are available for these systems except one (valonia oak system) because they have not been studied yet.

### *Aleppo Pine Forests*

Aleppo pine is a warm Mediterranean coniferous species distributed in several parts of the mainland as well as in the Ionian Islands. It has also been one of the main

species used in reforestation projects. It is a light-demanding tree. As a result, Aleppo pine forests have open crowns that allow the establishment of a rich understory mainly consisted of evergreen shrubs. Among these shrubs several herbaceous species can also be found. Aleppo pine is well adapted to recurrent wildfires and its forests are the most commonly burned forest areas in Greece. This is because the rich understory often results in the accumulation of high quantities of very flammable biomass (Liacos 1986; Kailidis 1990). In addition, it exerts a strong competition to the overstory for water and nutrients (Liacos 1986; Papanastasis 1986).

Aleppo pine forests have multiple uses. Trees can be used for timber and fuelwood production but mainly for resin and honey. Resin is used for glue and as a flavour additive to 'retsina', a popular Greek white wine. Honey is produced by bees fed on honeydew secretions of *Marchalina hellenica*, an insect endemic in the Aleppo pine forests of Greece (Schultz et al. 1987). Understory vegetation is used for fuelwood production but mainly for grazing by livestock. This vegetation is not usually of high feeding value but in the absence of better quality feed, it is often indispensable for livestock nutrition, especially for goats (Papanastasis 2001). For this reason, Aleppo pine forests have been traditionally used as silvopastoral systems. Livestock grazing, especially goats, can control the understory vegetation to the benefit of the trees (Liacos 1980, 1986; Papanastasis 1986, 2001).

## *Brutia Pine Forests*

Brutia pine is also a warm Mediterranean coniferous species distributed in the eastern part of the mainland, the Aegean islands and in Crete. It has been also extensively used in the establishment of artificial plantations, particularly in northern Greece. Its natural stands are open, because it is also a light demanding species. As a result, they support lush understory vegetation composed of different herbaceous or shrubby species (Liacos 1986). For this reason, brutia pine forests are very vulnerable to wildfires (Liacos 1986; Kailidis 1990).

It should be noted that the amount of the understory biomass and the species composition depend very much on the density of the overstory. In an experiment involving three spacings of an artificial plantation in northern Greece, it was found that both the amount of herbaceous understory and the tree diameter were increased as tree spacing increased (Platis et al. 1999; Mantzanas et al. 2001). Also, tree canopy helped maintain an average understory herbaceous biomass of 1,764 kg $ha^{-1}$ in August, almost as high as in May (1,713 kg $ha^{-1}$), suggesting that brutia pine silvopastoral systems can extend the grazing period into summer, when herbaceous species get dormant without tree canopy under semi-arid Mediterranean climatic conditions (Mantzanas and Papanastasis 2003).

Brutia pine forests are also multiple use forest systems. Their timber though is of better quality but the resin production is less than in Aleppo pine. On the other hand, brutia pine forests are traditional silvopastoral systems with livestock grazing, mainly goats, contributing to the control of understory vegetation and consequently

to the reduction of the fire risk (Tsiouvaras 2000). In addition, it helps maintain a high biodiversity including birds of prey, as it is the case of the Dadia forest (Bakaloudis et al. 1998).

## *Cypress Systems*

Cypress (*Cupressus sempervirens* L.) is distributed in the southern Aegean islands and in Crete where it forms natural forests alone or in mixture with brutia pine. It has been introduced deliberately throughout Greece, in both the eu- and the sub-Mediterranean zones. Its natural stands are open forests with rich understory vegetation composed of various phryganic and herbaceous species. Such understory vegetation makes cypress forests very vulnerable to wildfires, although cypress itself is not as flammable as brutia pine.

The natural cypress forests are limited in distribution and size. They are used for timber production and especially for grazing by livestock thus making them important silvopastoral systems. The same uses are also applied to its artificial plantations. These plantations are normally pure but cypress is also established in the borders of pine plantation in the form of narrow strips in order to protect them from wildfires. Nowadays, the most common use of cypress tree is for ornamental purposes along national roads, in urban parks, in churches and cemeteries. In addition, it is also planted in arable lands as a border tree to mark boundaries or for protection of crops from the strong winds (windbreaks). These latter uses result in silvoarable or agrosilvopastoral systems.

## *Kermes Oak Forests*

Kermes oak (*Quercus coccifera* L.) is an evergreen broadleaved tree species grown in the eu-Mediterranean and sub-Mediterranean zones of Greece. Due to its repeated cutting, burning and browsing however it is commonly found as a shrub forming extensive communities, pure or mixed with other evergreen or deciduous shrubs, which are known as ‘prinones’(kermes oak shrublands). ‘Prinones’ are mainly used for grazing by goats. Kermes oak trees, on the contrary, are only found in protected areas (e.g. urban and sub-urban forests, churches, cemeteries, private farms) either isolated or in small groves. Substantial areas of kermes oak trees are found only in certain parts of the mainland of Greece and in some islands, including Crete, where they form silvopastoral systems known as ‘prinodhasi’ (kermes oak forests). Other tree species may co-dominate with kermes oak.

Representative silvopastoral systems are found in Crete. They are usually grown in limestone areas and consist of a mixed understory with woody and herbaceous species. In such a system in the Psilorites mountain of Crete, the understory vegetation was composed of herbs (37 g $m^{-2}$) and shrubs (13 g $m^{-2}$) while the acorn yield was found to be 21 g $m^{-2}$. Sheep and goats consumed 73%, 29% and 89% of these yields respectively by the end of the growing period in June (Papanastasis and Misbah 1998).

## *Valonia Oak Systems*

Valonia oak (*Quercus ithaburensis* Decaisne ssp. macrolepis (Kotschy) Hedge & Yalt.) is a deciduous species grown in several parts of the mainland as well as in various islands with an eu- or sub-Mediterranean climate, covering a total area of about 30,000 ha (Fig. 5.2). Its natural stands are relatively small and usually pure; they are rarely intermixed with other deciduous oak species such as pubescent oak (*Q. pubescens* Willd.) and Italian oak (*Q. frainetto* Ten.). The understory vegetation is composed of both woody and herbaceous species (Pantera and Papanastasis 2001; Papanastasis 2002; Platis 2002).

Overstorey density amounts to 20–50 trees per hectare and its cover rarely exceeds 40% of the ground (Schultz et al. 1987). This means that valonia oak forests are open

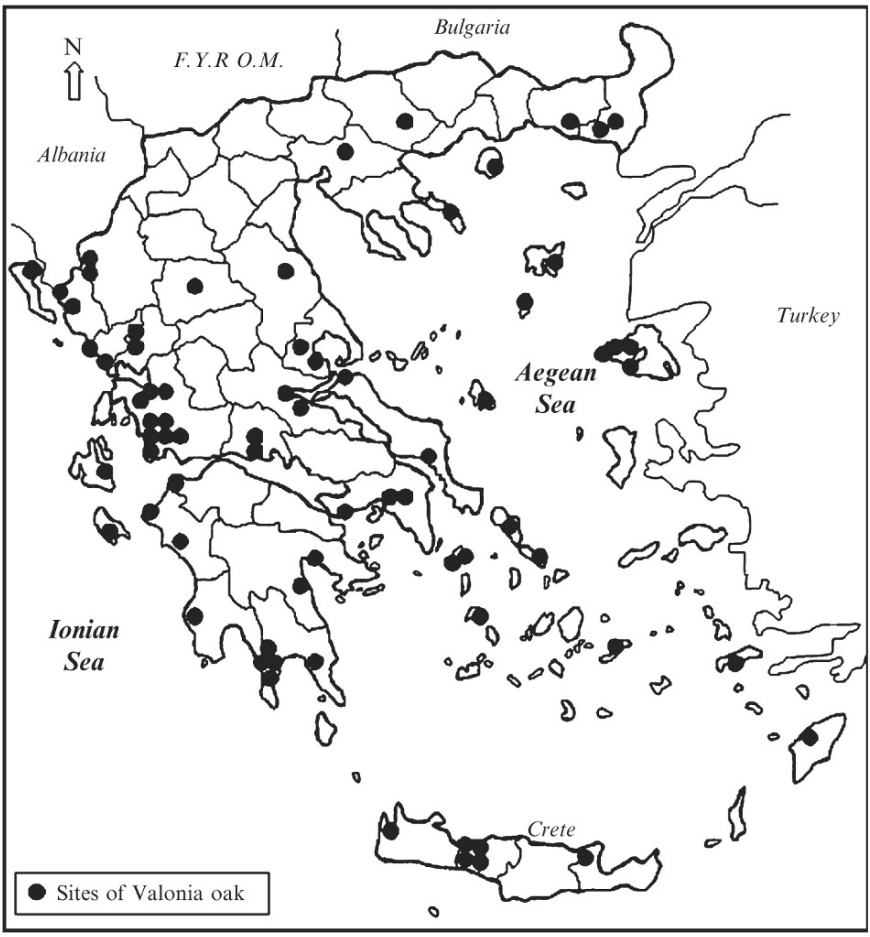


**Fig. 5.2** Distribution of valonia oak in Greece (Pantera and Papanastasis 2003)

and support rich understory vegetation. In two natural stands located in Thesprotia, western Epirus, the amount of understory vegetation was found to be 2,360 and 880 kg $ha^{-1}$ for woody [mainly Jerusalem sage (*Phlomis fruticosa* L.)] and herbaceous species respectively (Papanastasis 2002). In the Agrinio area, western central Greece, the amount of understory vegetation was found to be about 2,000 kg $ha^{-1}$, mainly consisted of herbaceous species, while the number of acorns fallen on the ground in December was found to be almost 8 acorns $m^{-2}$ (Pantera and Papanastasis 2001).

As a result of their open crowns and the substantial understory vegetation, valonia oak forests are ideal silvopastoral systems, equivalent to the dehesas and montados of Spain and Portugal respectively (Papanastasis 2002). Sheep are using not only the understory forage production but also the acorns of the oak trees (Pantera and Papanastasis 2001). In several parts of its distribution zone, valonia oak is grown within arable fields or in the borders of terraces cultivated with cereals. In these cases, it is part of silvoarable systems, or agrosilvopastoral if grazing is also applied after the harvest of the cereal crop. In addition to grazing, oak trees are also used for fuelwood production, when they are old enough and result in significant amounts per tree cut. The demand for valonia oak fuelwood is getting high nowadays. In the past, the cups of its acorns were extensively used for extraction of tannins used in the leather industry.

## *Macedonian Oak Forests*

Macedonian oak (*Quercus trojana* Webb.) is a deciduous oak tree, distributed in several parts of the mainland, particularly in western Macedonia where it is making extensive forests. These forests are either pure or mixed with other oak species such as pubescent, Italian, sessile [*Q. petraea* (Matt.) Liebl.] and Turkey oak (*Q. cerris* L.). However, most of natural stands are open thus supporting considerable understory vegetation, woody or herbaceous (Grove and Rackham 2001). Woody species may be several species of oaks (pubescent, Turkey, Italian) in a shrubby form as well as other shrubs [oriental hornbeam (*Carpinus orientalis* Mill.), manna ash (*Fraxinus ornus* L.)]. As a result of this rich understory vegetation, most Macedonian oak forests are used as silvopastoral systems for sheep and goats, which utilize not only the understory vegetation but also the fallen leaves and the acorns. In addition, oak trees are also used for the collection of fuelwood when they are old enough and result in significant amounts per tree cut. The demand for Macedonian oak fuelwood is getting high nowadays.

Macedonian oak is also found in silvoarable or agrosilvopastoral systems with arable crops, particularly cereals. In these systems, Macedonian oak is grown within or in the boundaries of the arable fields.

## *Other Deciduous Oaks Systems*

Other species of deciduous oaks are common forest species in Greece covering almost 1.5 million hectares (Ministry of Agriculture 1992). They include pubescent,

Italian sessile and Turkey oaks, all of them making high or coppice forests and primarily used for timber or fuelwood production. Although most of these forests are grazed by livestock, especially the coppice, they cannot be considered as silvopastoral systems because they are dense and therefore with limited understory vegetation while animals may damage their regeneration. Nevertheless, all these oak species form quite extensive silvoarable or agrosilvopastoral systems, particularly in the mountain areas. Isolated or small groups of these trees may be found within or in the boundaries of arable fields usually cultivated with cereals. The trees are used for fuelwood, fodder production (by shredding or pollarding), providing shade to livestock during midday in the summer or as markers of property boundaries. The arable fields are used for crops, particularly cereals, which are usually grazed after harvesting during summer. In some areas, the arable fields are cultivated with barley (*Hordeum vulgare* L.) or wheat (*Triticum aestivum* L.) not for grain production but as temporary pastures grazed during the winter or early spring.

## *Olive Tree Systems*

Olive tree is one of the most commonly cultivated trees in the eu-Mediterranean zone of Greece. It has been cultivated since the 1st century BC (Sallares 1991). It is grown in pure orchards but most commonly in mixture with other fruit or forest species on flat or very often on terraced land, within the arable fields or in their borders. Olive orchards are kept free of understory crops with repeated cultivation of the soil in order to enhance olive production. Most often however various crops are planted in the understory such as vineyards, cereals or forages thus resulting in typical silvoarable system. In several cases, pasture is established under the olive trees or spontaneous vegetation is grown that it is used for grazing by livestock resulting in silvopastoral systems. Finally, more complex systems such as agrosilvopastoral are formed when olive groves are grazed after the harvest of the crop, as it is the case of combining olive trees with cereals. In all these cases, olive trees are mainly grown for the production of olives but the pruned branches are also used as fuel as well as for feeding animals either *in situ* or in the barn.

## *Poplar Systems*

There are several species of poplars (*Populus* spp.), native or naturalized in Greece,but they occupy relatively limited area. On the contrary, artificial plantations with Lombardy poplar (*P. thevestina* Dode) and clones of hybrids between native and American species cover much larger area. These plantations contribute significantly to the timber production of Greece. Poplars are grown or planted in arable lands with good soils, irrigated or with good water conditions, such as water

canals and riverbanks. They are usually open and support understory vegetation, which is used for livestock grazing thus making them special silvopastoral systems (Schultz et al. 1987). The most common pattern though is the establishment of Lombardy poplar or hybrids along watercourses or around arable fields, cultivated with vegetables or other summer crops. This planting pattern results in typical silvoarable systems, which are traditional in several parts of Greece, particularly in the north. Poplars are used for timber production but also serve other purposes such as boundary marking or wind breaking.

## *Walnut Tree Systems*

Walnut is a common cultivated tree in the sub-Mediterranean and mountainous Mediterranean zones of Greece. It is planted in arable lands either in pure orchards or more commonly within arable fields or in their borders, alone or in mixture with other trees. It is usually combined with several crops, especially vineyards and cereals. In the former case it makes typical silvoarable; in the latter typical agrosilvopastoral systems are created that include livestock grazing after the harvest of the cereals. It is rarely used to establish pure silvopastoral systems. Walnut trees are used for the production of nuts, for high quality timber and for fuelwood.

Typical silvoarable systems combining walnut trees and vineyards, cereals, lucerne, vegetables or dry beans have been recorded in the Municipality of Askio, western Macedonia, in northern Greece (Mantzanas et al. 2006).

## *Almond Tree Systems*

Almond tree (*Prunus amygdalus* Batsch) is a common fruit cultivated in the eu-Mediterranean and sub-Mediterranean zones of Greece, particularly in the dry areas of the mainland and in the islands. It is planted alone or in mixture with other trees such as olives, figs, walnuts and pistachios in pure orchards or most commonly in combination with vineyards or herbaceous crops. Pure orchards are kept free of any understory by frequent cultivation or use of herbicides. Joint cultivation with other crops is common in several parts of the country resulting in a typical silvoarable system. Herbaceous crops may include cereals, tobacco, forages and legumes. If also grazed after the harvest of the crop then agrosilvopastoral systems may be formed. Pure silvopastoral systems are rarely found.

Typical silvoarable systems combining almond trees and cereals (e.g. barley, wheat), lucerne or vineyards are found in the Municipality of Askio, western Macedonia, in northern Greece (Mantzanas et al. 2006). Also, extensive silvoarable systems of almond trees and cereals or vineyards are found in several Aegean islands.

## Evolution of Agroforestry Systems

Traditional agroforestry systems have been considerably degraded during recent decades and especially after World War II. This degradation can be attributed to the decline in agriculture in the Greek countryside. This is due, on the one hand, to the rural exodus and migration of more than one million people in the period 1950–1970, who left agriculture and the rural areas for the urban centres and abroad and, on the other, to the agricultural modernization (Kasimis and Papadopoulos 2001). Since agroforestry systems are labour-intensive economic systems (Papanastasis 2004a), their function was significantly affected by the rural exodus, which largely involved the most economically active population. According to Tsoumas and Tasioulas (1986), agricultural abandonment was more pronounced in the mountainous areas, where arable lands are marginal and therefore more sensitive to market changes. Agricultural mechanization, particularly the introduction of the tractor in the past as well as the European Union support policy through subsidies did not lead to any structural improvement of family farms, especially in the marginal rural areas, mainly due to the small land ownership (Kasimis and Papadopoulos 2001).

According to Papanastasis (2004a), degradation of agrosilvopastoral systems may be caused by two opposing human actions, extensification and intensification. Traditional agroforestry systems in Greece have suffered from both these processes. They can be seen better if examined separately on forest and agricultural lands.

### *System Degradation on Forest Land*

The degradation processes mostly affecting agroforestry systems on forest land are extensification and abandonment. Most of these systems have been maintained over the centuries through the following main human activities: wood cutting, charcoal and firewood harvesting, resin collection (in Aleppo and brutia pine forests) and livestock grazing (Papanastasis 2004b). All these activities have declined or even stopped in several parts of Greece over the last few decades. In western Crete, for example, the area covered by coniferous forests was increased by 20% from 1945 to 1989, but the area covered by dense (more than 70% tree cover) forests increased by 70% (Papanastasis and Kazaklis 1998). This increase seems to be the result of the decrease in human population in mountainous areas of that particular region and the concomitant reduction or ceasing of activities, especially livestock grazing (Ispikoudis et al. 1993). Similar results were found in Pindus mountain, in Central Greece, where the area of shrublands and especially forests increased between 1945 and 1992 at the expense of grasslands and arable lands, leading to dense stands (>70% tree cover). This was due to the reduction of the active human population and its traditional activities (Chouvardas 2001). In Lagadas County, Northern Greece, the area of kermes oak shrublands and deciduous oak forests increased and became denser between 1960 and 1993 as a result of the reduction of human

population and its activities such as charcoal collection and livestock grazing (Chouvardas et al. 2006).

As far as the relation between livestock husbandry and agroforestry is concerned, Ispikoudis et al. (2004) have pointed out the importance of transhumance, a traditional pastoral activity which has created special landscapes in mountainous areas characterized by silvopastoral systems based on deciduous oaks and pines. Although transhumance is still practiced today, the number of animals involved has dramatically decreased. For example, the percentage of the total number of sheep involved was 15% in 1961 to get reduced to 7% in 2001 while for goats the respective percentages were 13% and 5% (National Statistical Service of Greece 2005). Also, the system applied has been significantly modified compared to the past largely as a result of the socio-economic changes which occurred during the last century. Typical silvopastoral systems involving 'kladonomi' (shredding) and 'koura' (pollarding) are still visible in several parts of Greece but they are rapidly fading down due to the interruption of the traditional tree management techniques (Fig. 5.1). Such an evolution has resulted in a considerable loss of cultural heritage.

Intensification has had a limited impact on agroforestry systems on forest land and it is largely localized. Overgrazing leads to the degradation of these systems by inhibiting tree regeneration and causing soil erosion. This is the case in the Psilorites mountain in Crete, where forests were reduced by about 9% but dense forest (more than 70% tree cover) by 33% as a result of a sharp increase in livestock numbers (by 290%) between 1971 and 1991 (Bankov 1998) primarily due to national and especially the European subsidies (Zioganas et al. 1998).

## *Systems Based on Agricultural Land*

Degradation of agroforestry systems on agricultural land has been caused by both extensification and intensification processes. Extensification has mostly affected the systems on remote hilly and mountainous regions where the rural population exodus deprived these areas from the necessary labour to tend and maintain the systems resulting in their abandonment and breakdown. In some areas with acute labour problems, the traditional silvoarable systems have been completely neglected and degenerated. In the remote region of Sougia of western Crete, for example, agricultural land was decreased by 38% between 1945 and 1989, due to the reduction of the human population by 47% resulting in the breakdown of silvoarable systems involving olive, fig, and almond trees with cereals (Papanastasis et al. 2004). In other areas, where the lack of labour was not so acute, the traditional silvoarable systems have been simplified and converted to cropland. This happened in the case of the Municipality of Askio in western Macedonia, North Greece, where 32 types of traditional silvoarable systems were recorded combining a variety of cultivated and native trees with several crops, but only the crops are maintained by farmers due to the subsidies provided by European Union (Mantzanas et al. 2005).

Intensification, on the other hand, mostly affected the agroforestry systems grown in plains and in highly populated areas. In these areas, several projects involving drainage, land consolidation and irrigation have resulted in the conversion of the traditional agroforestry systems into intensively cultivated monocultures of trees or arable crops. Trees, in such cases, are considered as obstacles to agricultural equipment and they are partially or completely removed to facilitate the cultivation of the arable land. This evolution has happened in all major agricultural plains of Greece. A typical case is the Alikianou basin near the city of Chania in western Crete, where traditional cereal agriculture was replaced by intensively cultivated monocultures of citrus and olive groves in the last 50 years (Papanastasis et al. 2004).

### *Establishment of New Systems*

In the last few years, a number of experiments were carried out aiming at establishing new agroforestry systems, which are sustainable under the current socio-economic conditions. They included the establishment of silvopastoral systems, based on fodder trees such as black locust (*Robinia pseudoacacia* L.) and mulberry (*Morus alba* L.) (Papanastasis et al. 1999) and on timber trees such as sycamore (*Acer pseudoplatanus* L.)and Scotch pine (Nastis et al. 1997; Gakis et al. 2004), as well as silvoarable systems combining timber trees [e.g. walnut, wild cherry (*Prunus avium* L.)] and various crops [e.g. wheat, maize (*Zea mays* L.)] (Mantzanas et al. 2005). None of these attempts however have attracted farmers who need special financial incentives to establish and maintain these trees or plant new ones in their fields (Mantzanas et al. 2005). It is expected that this attitude of the farmers will change soon since agroforestry has been recently incorporated in the EU agricultural policy and farmers will be financially assisted to promote this practice all over Europe, including Greece (Christidis 2005).

## Conclusions and Recommendations

Traditional agroforestry systems are invaluable biological, economic and cultural resources in Greece that need to be protected and properly improved in order to become economically sustainable under current socio-economic conditions. Such an objective though cannot be implemented if their structure and distribution is not thoroughly explored. It is recommended that a special program should be developed to quantify traditional agroforestry systems by utilizing all the existing information and applying modern technology, including remote sensing and GIS. Subsequently, detailed studies need to be carried out in order to investigate their economic and environmental capacities so that their sustainable management is planned and implemented.

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